I.S.A. Istrumentazioni Sistemi Automatici S.r.l.
Via Prati Bassi 22 - 21020 Taino (VA) - ITALIA
tel +39 0331 956081 - fax +39 0331 957091
e-mail: isa@isatest.com - www.isatest.com

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SINGLE PHASE RELAY TEST SET

MOD. T1000

REVISIONS			SUMMARY	VISA
N	PAGE	DATE		
1	All	26/09/2002	Preliminary issue	Lodi.
2	All	04/10/02	Preliminary issue	Lodi
3	26	8/7/2003	Added the optional cable set paragraph	Lodi
4	4	1/12/2003	Modified to 1.4 kV the dielectric rigidity	Lodi
5	29, 30	24/8/2004	Added D/1000 option	Lodi
6	18	22/01/2005	Increased the AC voltage measurement ranges	Lodi
7	15; 17	02/02/2006	Added the range change values	Lodi
8	30	22/10/2006	Added the 15 Hz option and “E” option, plus the test of thermal protection and circuit breakers.	Lodi
9	30	10/8/2007	Added the C model	Lodi
10	30	9/4/2008	Added information for the 110 V model	Lodi

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APPLICABLE STANDARDS

The test set conforms to the EEC directives regarding Electromagnetic Compatibility and Low Voltage instruments.

A) Electromagnetic Compatibility:
Directive no. 89/336/CEE dated may 3, 1989, modified by the directive 92/31/CEE dated may 5, 1992. Applicable Standard : EN61326 + A1 + A2.

EMISSION

- EN 61000-3-2: Harmonic content of power supply. Acceptable limits: basic.
- EN 61000-3-3: Limitation of voltage fluctuations and flicker. Acceptable limits: basic.
- CISPR16 (EN 55011 class A): Limits and measurement methods of radio-electric disturbances for industrial, medical and scientific instruments at radio-electric frequencies.

Acceptable limits for conducted emission:
. 0.15-0.5 MHz: 79 dB pk; 66 dB avg.
. 0.5-5 MHz: 73 dB pk; 60 dB avg.
. 5-30 MHz: 73 dB pk; 60 dB avg.
Acceptable limits for radiated emission:
. 30-230 MHz: 40 dB (30 m)
. 230-1000 MHz: 47 dB (30 m)

IMMUNITY

- EN 61000-4-2: Immunity tests for ESD. Test values: 8 kV in air; 4 kV in contact.
- EN 61000-4-3; Immunity tests for radio frequency interference. Test values (f= 900 ± 5 MHz): field 10 V/m, modulated AM 80%; 1 kHz
- EN 61000-4-4; Immunity tests for high speed transients (burst). Test values: 2 kV peak; 5/50 ns.
- EN 61000-4-5; Immunity tests for surge. Test values: 1 kV peak differential mode; 2 kV peak common mode; 1.2/50 us.
- EN 61000-4-6: immunity to low-voltage sinusoidal waveform. Test values: 0.15-80 MHz, 10 Vrms, 80% AM 1 kHz.
- EN 61000-4-8: Immunity tests for low frequency magnetic fields. Test values: 30 Arms/m.
- EN 61000-4-11: Immunity test for power supply drops. Test value: 1 cycle; 100% drop.

B) Low Voltage Directive:
- Directive n. 73/23/CEE, modified by the directive 93/68/CEE.
- Applicable standard: EN 61010-1. In particular, for a pollution degree 2: dielectric rigidity 1.4 kV AC, 1 minute.
- Inputs/outputs protection: IP 2X - EN60529.
- Operating temperature: 0 to 50 °C; storage: -20 °C to 70 °C.
- Relative humidity : 5 - 95%, without condensing.
- Vibration: IEC 68-2-6 (20 m/s^2 at 10 – 150 Hz);
- Shock: IEC 68-2-27 (15 g; 11 ms; half-sine).
- Altitude: less than 2000 m.

1 INTRODUCTION

The single phase relay test set mod. T1000 is suited for the testing and adjustments of the following types of relays.

Type of relay	**IEEE code**
- Distance*	21
- Synchronizing	25
- Thermal	26
- Over/under-voltage	27 - 59
- Power, varmetric or wattmetric	32 - 92
- Under current	37
- Reverse phase current	46
- Instantaneous overcurrent	50
- Ground fault	50N
- Timed overcurrent	51
- Circuit breaker	52
- Power factor	55
- Directional overcurrent	67
- Directional ground fault	67N
- Automatic reclose	79
- Frequency	81
- Frequency rate of change	81
- Motor protection	86
- Differential **	87
- Directional voltage	91
- Tripping relay	94
- Voltage regulation	
- Thermal	
- Timers	

* For distance relays three T1000 are necessary.
** Differential starter circuit

In addition to the above, T1000 can test:
. Converters: V; I; f °; p.f.; W; VAr; f., both 0 to 5 and 4 to 20 mA.
. Energy meters, single phase or three phase.

The instrument contains three separate generators:
. Main generator: it generates either AC current, AC voltage; DC voltage;
. Auxiliary a.c voltage generator: it generates an independent, phase adjustable a.c voltage;
. Auxiliary DC voltage generator: it generates the DC voltage that feeds the relay under test.

All outputs are adjustable and metered at the meantime on the large, graphic LCD display. With the multi-purpose knob and the LCD display it is possible to enter the MENU mode, that allows to set many functions, that make T1000 a very powerful testing device, with manual and semi-automatic

testing capabilities, and with the possibility to transfer test results to a PC via the RS232 interface. These results can be recorded, displayed and analysed by the powerful TDMS software, that operates with all WINDOWS versions, starting from WINDOWS 98 included.

The basic T1000 function is to generate current and voltages and to stop generation as the relay trips. Test results are kept in memory, and can be transferred to a PC at a later time, along with settings.
The ease of operation has been the first goal of T1000: this is why the LCD is graphic, and so large. With it, the dialogue in MENU mode is made easy. Besides, all T1000 outputs are continuously measured, and output values are displayed, with no extra effort to the operator. Also the show waveform feature can be of help: any doubt about strange measurements, distortion and so on can be solved.

This is also why we have added the reduced power feature. Modern relays have a very low burden. As current output is a low impedance voltage generator, adjusting low currents and/or current on low burdens is quite difficult because one has to operate at the very beginning of the adjustment knob. In this situation it is possible to connect resistors in series; however, one must be careful not to exceed the maximum current rating, and the wiring is more complicated. The solution to this problem is just to reduce the available power: this is easily performed via the multi-function knob. With less power, the maximum voltage is reduced by a factor of 4.4; the adjustment span on the knob is increased accordingly.

Additional features are:
. Two meters, current and voltage, with independent inputs, allow measuring T1000 outputs or any other source;
. An auxiliary contact, that follows START and STOP inputs, allows simulating the circuit breaker;
. A set of resistors allows easing output adjustment.

The instrument is housed in a transportable aluminium box, that is provided with removable cover and handles for ease of transportation.

NOTE: WINDOWS is a trademark of MICROSOFT inc.

2 CHARACTERISTICS

2.1 MAIN GENERATOR

The main generator has three outputs: currents, voltage AC, voltage DC. The following specification apply to the separate usage of these outputs. It is possible to use them at the meantime, provided that the total maximum load is not exceeded.

The main generator is made of a variable transformer followed by a transformer. The variable transformer does not reach the zero position; so, when you are adjusting the output current on a low burden, the minimum current can be up to 5% of the range. If this is a problem, select the 60 VA power: the current is reduced to one fifth.

2.1.1 Main AC current

- Type of generator: voltage, high current output: the current depends upon the burden.

- On all outputs is provided the capability of generating the selected current at maximum power or at reduced power. Reduced power selection eases the current adjustment for modern relays, where the load is negligible. Current ranges; available power; duty cycle: see the table below.

1) MAXIMUM POWER 300 VA

RANGE A AC	CURRENT OUTPUT A	MAXIMUM POWER VA	LOAD TIME s	RECOVERY TIME min
100	30	300	STEADY	-
	50		30 min	100
	75		600	45
	100	800	60	15
	150		3	10
	250	1000	1	5
40	12	300	STEADY	-
	20		30 min	100
	30		600	45
	40	800	60	15
	60		3	10
	80	1000	1	5
10	5	400	STEADY	-
	7.5		15 min	45
	10	800	60	15
	15		5	10
	20	1000	2	5

2) MAXIMUM POWER 60 VA

RANGE A AC	CURRENT OUTPUT A	MAXIMUM POWER VA	LOAD TIME s	RECOVERY TIME min
100	30	60	STEADY	-
	38		10 min	45
	53		60	10
	70		0.75	2
40	12	60	STEADY	-
	17		10 min	45
	23		60	10
	36		1	2
10	5	60	STEADY	-
	6		10 min	45
	7		60	2
	10		1,5	2

- Power selection: via menu.

- Connection: four high power sockets, with safety protections, marked: 0; 10 A; 40 A; 100 A.

2.1.2 Main AC voltage

- The main AC voltage is isolated from the main AC current.

- AC voltage range: 250 V or 54 V (reduced power; power supply 230 V), or 108 V (reduced power; power supply 115 V).

- Available power and duty cycle: see table below.

RANGE V AC	VOLTAGE OUTPUT V	LOAD CONSUMPTION VA	LOAD TIME min	RECOVERY TIME min	REDUCED POWER VA
250	250	500	STEADY	-	60
	250	750	10	45	-
54 (108)	54 (108)	60	STEADY	-	60

- Connection: two safety banana sockets.

2.1.3 Main DC voltage

- The main DC voltage is isolated from the main AC current, but not from the main AC voltage

- DC voltage range: 300 V or 60 V (reduced power; power supply 230 V), or 120 V (reduced power; power supply 115 V).

- Available power and duty cycle: see table below.

RANGE V DC	VOLTAGE OUTPUT V	LOAD CONSUMPTION W	LOAD TIME min	RECOVERY TIME min	REDUCED POWER W
300	300	300	STEADY	-	60
	300	500	10	45	-
60 (120)	60 (120)	60	STEADY	-	60

- Type of DC voltage: unregulated, via diode bridge rectifier and capacitor.

- Connection: two safety banana sockets.

2.1.4 Other features of main outputs

- Zero crossing control. Main AC outputs are generated and stopped as the output waveform crosses zero. This implies that in mode ON+TIME the output drops to zero from 0 to one cycle after STOP is detected.

- Overload alarm message. When the nominal current range is trespassed a message is displayed.

- Thermal protection: by NTC. Trespassing of the maximum temperature is signalled by a message.

- Output adjustment: from less than 5% to 100% of the output.

- Output measurement. The used output (current, Vac, Vdc) is selected by a dedicated push-button; the selected socket is confirmed by a light.

2.2 AUXILIARY AC VOLTAGE

- The auxiliary AC voltage output, Vac aux, is isolated from the main AC current and voltage.
- Output ranges: 65 – 130 - 260 V.

- Range selection: software driven, by the multi-function knob and LCD display.

- Auxiliary voltage power: 30 VA, continuous duty, at full range; 40 VA for 1 minute. For lower voltages the limiting current is the following.

RANGE V	MAX CURRENT mA
65	500
130	250
260	125

- Output stability: the adjusted voltage drops of 5% maximum from zero load to full load.

- Output adjustment: continuous. For normal tests the voltage is continuously supplied, and the output voltage is adjusted by the dedicated knob.

- Output connection: safety banana sockets.

- Possibility to phase shift the auxiliary AC voltage output with respect to: the main current and the main AC voltage. The phase angle reference is the auxiliary voltage. Phase shifter characteristics:
. Phase angle adjustment: via the multi-function knob.
. Phase angle range: from 0° to 360°.
. Adjustment resolution: 1° (degree).

- Possibility to define the pre-fault voltage: in this mode, the control knob allows to adjust the pre-fault value, while the dedicated knob adjusts the fault value. Voltage output selection is automatic: pre-fault voltage with test stopped; fault voltage with test started. The switch from a value to the other one is performed without falling to zero. The main current or voltage is generated at the zero crossing; the fault one is generated at the meantime of main voltage or current (figure 1). The selection of the reference is performed automatically, following the selection of main output measurement. If the main DC voltage is selected the reference is taken on the main AC voltage.
This feature allows testing voltage relays (27-59) or synchronizing relays (25).

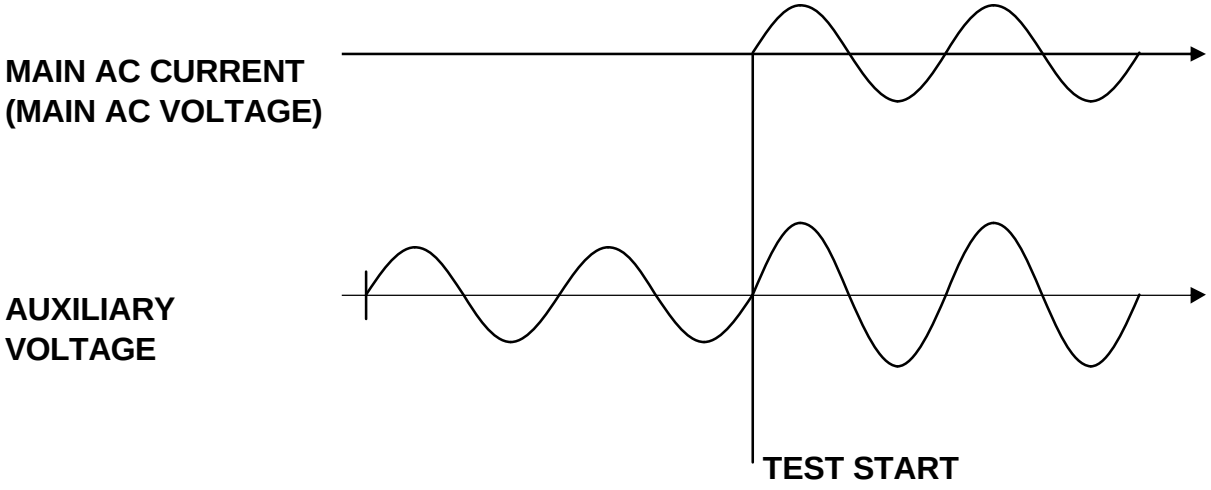


Figure 1 - Output voltage control

- Possibility to phase shift the pre-fault voltage with respect to the fault voltage. This parameter serves during the test of distance relays, when phase to phase faults are simulated: as test starts, the auxiliary voltage changes amplitude and phase with respect to the pre-fault value (figure 2)

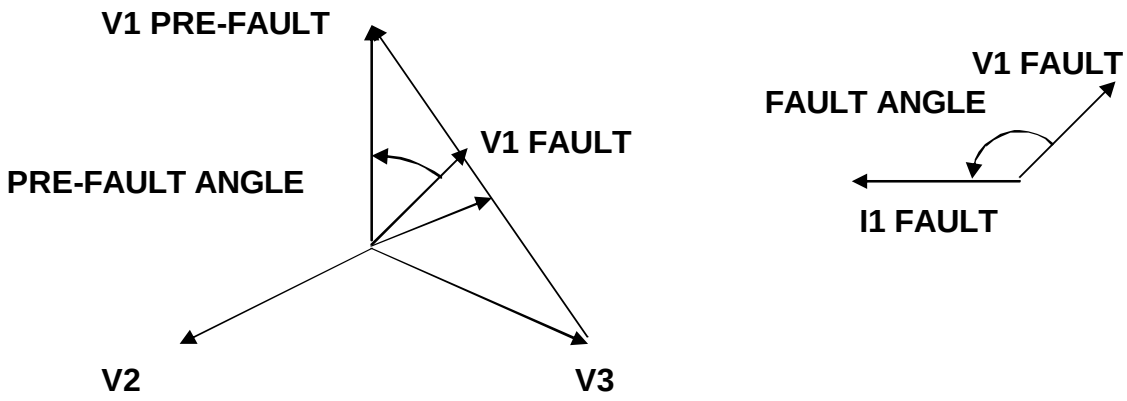
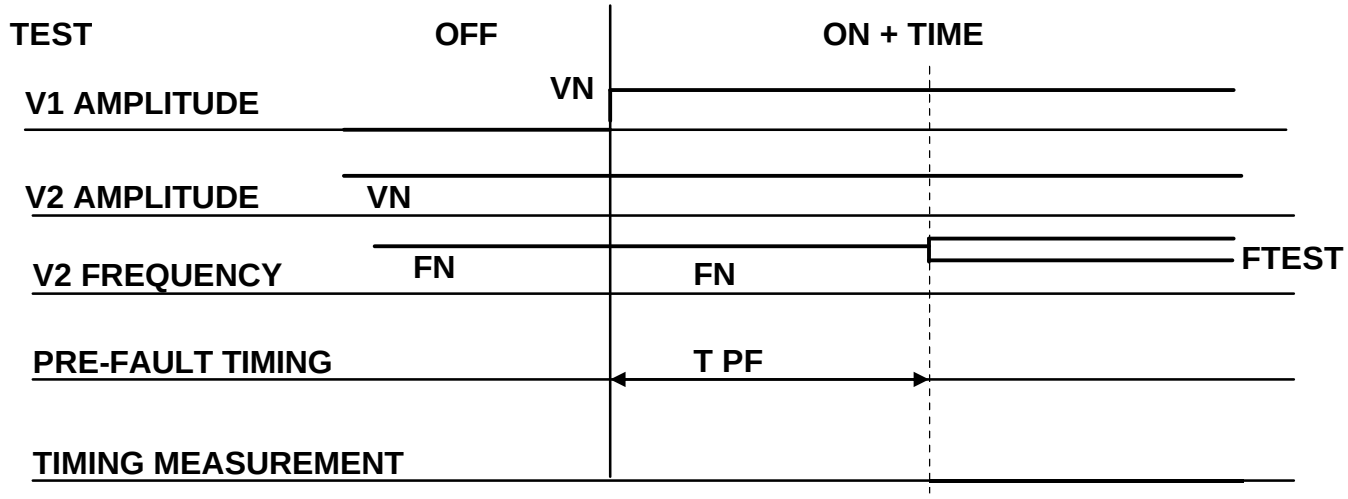


Figure 2 – Pre-fault voltage angle definition

- Possibility to define the duration TPF of pre-fault generation, after test start, prior to generating fault values. This feature is necessary to test synchronization relays: the main output voltage can be applied prior to frequency switching. TPF range: from 0 to 999.99 s.



- Possibility to change the frequency of the auxiliary AC voltage output. Frequency generation characteristics:
. Frequency range: 40 Hz to 500 Hz.
. Frequency adjustment: 1 mHz, via control knob.
. Frequency generation error: 100 ppM.
. Possibility to switch from the nominal frequency to the fault one. The nominal frequency is also selectable, independently from the fault.
. Switching from nominal frequency to fault frequency is performed without altering the output voltage (figure 3).

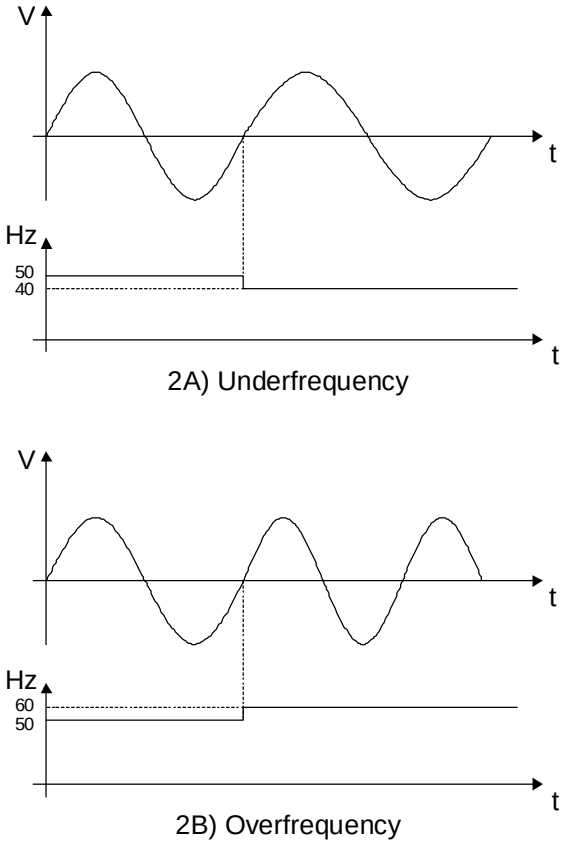


Figure 3 - Frequency relay test waveform

- Possibility to test frequency rate of change relays. Frequency ROC range: from 0.01 to 99.99 Hz/s. The frequency change stops at 40 or 70 Hz.

2.3 AUXILIARY DC VOLTAGE

- The auxiliary DC voltage output, Vdc aux, is isolated from the main AC current and voltage and from the auxiliary AC voltage output.

- DC voltage range: 130 V or 240 V.

- Output adjustment: continuous, by knob, from 20 V to the selected range.

- DC voltage power: 90 W at full range, continuous duty, with a current limit of 0.9 A @ 130 V and 0.45 A @ 240 V.

- DC output accuracy:
. For mains supply variations: ± 1%;
. For load changes: ± 1%;
. Residual ripple: 1%.

- Output connection: on safety banana sockets.

2.4 TIMER

The electronic digital timer has a fully automatic start and stop, both for make and break of the input, that can be either a clean contact or an contact under voltage . All selections are menu-driven via the multi-function knob.

- Characteristics of Start and Stop inputs:
.. Inputs do not have any common point, and are optocoupled from the instrument at 1.35 kV AC;
.. Inputs connection: two banana sockets per input;
.. Inputs may be independently selected as Normal Open or Normal Close;
.. It is also possible to select timer start or stop as the current is injected and timer start/stop on input transition;
.. Selections are displayed on the front panel by 10 dedicated lights;
.. Type of input: either clean or under voltage; selection via the multi-function knob. Maximum input: 250V a.c or 275 V DC;
.. For both inputs, when the input is closed or with voltage an LED turns on;
.. When the relay intervenes the TRIP light turns on;
.. Wrong selection protection. If voltage is applied when clean input is selected, input circuits are not damaged.

- Input thresholds: when the contact has voltage applied, two thresholds can be selected. The low setting applies to nominal voltages of 24 and 48 V; the high setting to 110 V up.

With voltage

Parameter	Nominal value	Unit
Low setting	12	V DC
High setting	80	V DC

Without voltage

Parameter	Nominal value	Unit
Nominal wetting voltage	24	V
Nominal wetting current	10	mA

- Available measurements:
. Timer start: at test start, or by an external contact;
. Metering of elapsed time between START and STOP.

- Time can be metered as seconds or cycles. Metering range, in seconds: see table.

Range	Resolution	Accuracy
From 0 to 9.999 s	1 ms	± (1 ms + 0.005%)
From 10.00 to 99.99 s	10 ms	± (10 ms + 0.005%)
From 100.0 to 99999.9 s	100 ms	± (100 ms + 0.005%)

. Metering range, in cycles: see table.

Range	Resolution	Accuracy
From 0 to 999.9 cycles	0.1 cycles	± (0.1 cycle + 0.005%)
From 1000 to 4999995 cycles @ 50 Hz	1 cycle	± (1 cycle + 0.005%)
From 1000 to 5999994 cycles @ 60 Hz	1 cycle	± (1 cycle + 0.005%)

- Display reset: automatic, at test start.

- Counting mode: this mode is foreseen for the test of energy meters. Maximum input frequency: 10 kHz; voltage threshold can be set as for tripping. It is possible to select this mode via menu, and to set the number of impulses; the test set counts all impulses applied to START input after ON and during all generation, and measures the time elapsed during the count.

2.5 TEST CONTROL

- Manual start control:
. OFF: main outputs are not generated; Vac aux is generated, and it can be either the pre-fault value or the fault value, according to selections; Vdc aux is generated.

. ON: main outputs are generated; Vac aux has the fault value. In this situation it is possible to verify and memorize the relay threshold, both trip and reset.

. From OFF to ON + time: main outputs are generated and the timer starts according to selections; as STOP is sensed, main outputs are removed and the elapsed time displayed and test result can be memorized.

. From ON to OFF + time: main outputs are removed the timer starts according to selections; as STOP is sensed, the elapsed time is displayed and test result can be memorized.

. Test control: by two push-buttons.

- Other test control selections:
. Momentary: in ON mode, main outputs are generated until the push-button is pressed;

. Timed: main outputs are generated for the programmed maximum time;

. External. This mode allows for the synchronization of more T1000;

- Reclose test. It is possible to select via menu the test of a reclosing scheme. In this operating mode T1000 automatically applies current with a programmable delay TD after the RECLOSE command is sensed at START input. The test set measures and stores the trip delay and the delay between trip falling edge and RECLOSE trailing edge (see figure 4). Range of TD: from 0 to 999.99 ms. Maximum number of Reclose commands: 49; maximum test duration for all Reclose commands: 9999 s.

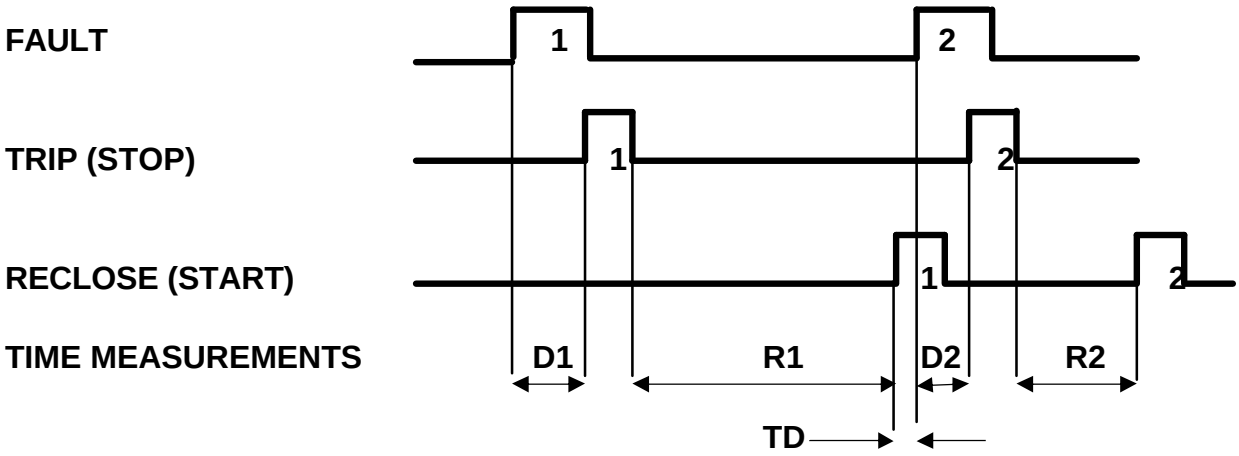


Figure 4: Measure of Delay and Reclose times

- Circuit breaker delay simulation: possibility to set the delay from relay trip to generation off. Delay range: 0 to 999 ms or 0 to 999 cycles.

- Save selections:
. No automatic saving.
. Test data can be saved after confirmation. After relay trip, pressing the multi-function knob it is possible to save the test result.

2.6 AUXILIARY CONTACT

- The auxiliary make and break contact, closes (opens) at test start, and opens (closes) as current is cut off after the STOP input is sensed. Maximum time error between current and make/break contact: 1 ms.

- The contact can also be used to simulate the circuit breaker state. Maximum error between current start after the trip command and make/break: 1 ms.

- Possibility to delay the auxiliary contact switch with respect to test start. Delay range: from 0 to 99.99 s.

- Contacts range: 5 A; 250 V AC; 120 V DC

2.7 OUTPUTS MEASUREMENT

2.7.1 Current and voltage

- The following three outputs are displayed at the meantime on the LCD:
. The selected main output: AC current, or AC voltage, or DC voltage;
. Auxiliary AC voltage output;
. Auxiliary DC voltage output.

- Type of measurement: true rms for AC outputs; average for DC outputs.

- Readings, resolution and accuracy: see table. Note that the available ranges can be greater than the maximum value of the output to which the load is connected: this means that higher values can be measured without saturation. For example, on the 100 A output the measuring range is up to 999 A. Actually, the test set will not generate more than 250 A, as the test is stopped by the software, that indicates overload, and on the display currents more than 250 A will not be shown.

OUTPUT	**RANGE**	**CHANGE RANGE**	**RESOLUTION**	**ACCURACY**
10 A	1.999 A	1.5 A	1 mA	± (1% + 5 mA)
	19.99 A		10 mA	± (1% + 20 mA)
40 A	7.999 A	6 A	4 mA	± (1% + 20 mA)
	79.99 A		40 mA	± (1% + 80 mA)
100 A	19.99 A	15 A	10 mA	± (1% + 50 mA)
	199.9 A	150 A	100 mA	± (1% + 200 mA)
	249.9 A		100 mA	± (1% + 200 mA)
250 V AC	19.99 V	15 V	10 mV	± (1% + 50 mV)
	199.9 V	150 V	100 mV	± (1% + 200 mV)
	299.9 V		300 mV	± (1% + 300 mV)
300 V DC	19.99 V	15 V	10 mV	± (0.5% + 50 mV)
	199.9 V	150 V	100 mV	± (0.5% + 200 mV)
	299.9 V		300 mV	± (0.5% + 300 mV)
65, 130 V AC	19.99 V	15 V	10 mV	± (1% + 20 mV)
	199.9 V		100 mV	± (1% + 200 mV)
260 V AC	19.99 V	15 V	10 mV	± (1% + 20 mV)
	199.9 V	150 V	100 mV	± (1% + 200 mV)
	299.9 V		300 mV	± (1% + 300 mV)
130 V DC	19.99 V	15 V	10 mV	± (0.5% + 100 mV)

	199.9 V		100 mV	± (0.5% + 200 mV)
260 V DC	19.99 V	15 V	10 mV	± (0.5% + 100 mV)
	199.9 V	150 V	100 mV	± (0.5% + 200 mV)
	299.9 V		300 mV	± (0.5% + 300 mV)

NOTES:

- The change range is the actual value at which the range is changed. This avoids saturation problems when we have to measure fast-changing values.

- Metering temperature coefficient: ± 0,05%/°C of the value ± 0,02%/°C of the range.

- Via menu selections the metering can also be referred to the nominal current or voltage. In this situation the following applies.

OUTPUT	**NOMINAL VALUE RANGE**	**NOMINAL VALUE STEP**	**MEASUREMENT RANGE %**	**RESOLUTION %**	**ACCURACY %**
CURRENT	1 – 999 A	1 A	99.9	0.1	0.1
			999	1	1
VOLTAGE AC	1 – 999 V	1 V	99.9	0.1	0.1
			999.9	1	1

- Measurement options: see the MENU paragraph.

2.7.2 Phase angle

- The auxiliary voltage is the reference for the measurement of the phase shift of one of the following parameters:
. The main current;
. The main AC voltage;
. The mains supply.

- Readings, resolution and accuracy: see table.

MEASUREMENT	**RANGE**	**RESOLUTION**	**ACCURACY**
PHASE	0 - 360	1°	1° ± 1 DIGIT *

* Specified accuracy applies for outputs I,V or V,V greater than 20% of the selected range.

- Phase angle temperature coefficient: ± 1 ppM/°C of the value.

2.7.3 Other measurements

Starting from the above measurements, the test set can compute derived measurements; the selection is performed via the control knob.
The following is the list of available measurements. For all of them the following range and resolution applies; the accuracy is the sum of voltage, current and possibly angle accuracy.

PARAMETER RANGE; X IS THE MEASURED ENTITY	**RESOLUTION**
0 – 999 mX	0,001 X
1.00 – 9.99 X	0,01 X
10.0 – 99.9 X	0,1 X
100 – 999 X	1 X
1.00 – 9.99 kX	10 X
10.0 – 99.9 kX	100 X
100 – 999 kX	1000 X

N.	**PARAMETER , AC outputs**	**DERIVED FROM**	**FORMULA**	**UNITS**
1	ACTIVE POWER, P	Imain, Vac aux; f	P= I*V*cos (f)	W
	REACTIVE POWER, Q	Imain, Vac aux; f	Q= I*V*sin(f)	VAr
2	APPARENT POWER, S	Imain, Vac aux	S= I*V	VA
	POWER FACTOR, p.f.	f	p.f. = cos(f)	-
3	IMPEDANCE, Z and f	Imain, Vac aux, f	Z = V/I	Ohm, °
4	ACTIVE IMPED. COMPONENT, R	Imain, Vac aux; f	R = Z* cos(f)	Ohm
	REACTIVE IMPEDANCE COMP., X	Imain, Vac aux; f	X = Z* sin(f)	Ohm

2.8 EXTERNAL INPUTS MEASUREMENT

- It is possible to meter the current and the voltage of an external (or internal) generator.

- Input connection: by four safety sockets; three for current and two for voltage.

- Metering circuits are 1.35 kV isolated between them and from the rest of the instrument.

2.8.1 Current measurement

- Maximum input current. Two inputs: 20 mA or 10 A, AC or DC

- Range, resolution, accuracy: see table below.

RANGE 20 mA	**RESOLUTION**	**ACCURACY**
25 mA DC	0.1 mA	± (0.5% + 0.1 mA)

RANGE 10 A	**CHANGE RANGE**	**RESOLUTION**	**ACCURACY**
1.999 A AC	1.5 A	1 mA	± (1% + 2 mA)
10.49 A AC		10 mA	± (1% + 20 mA)
1.999 A DC	1.5 A	1 mA	± (0.5% + 2 mA)

10.49 A DC		10 mA	± (0.5% + 20 mA)

- Metering temperature coefficient: ± 0,05%/°C of the value ± 0,02%/°C of the range.

- Possibility to display the current waveform.

2.8.2 Voltage measurement

- Maximum input voltage: 600 V, AC or DC

- Range, resolution and accuracy: see table below.

RANGE	**CHANGE RANGE**	**RESOLUTION**	**ACCURACY**
19.99 V AC	15 V	10 mV	± (1% + 20 mV)
59.99 V AC	45 V	10 mV	± (1% + 60 mV)
199.9 V AC	150 V	100 mV	± (1% + 200 mV)
599.9 V AC		100 mV	± (1% + 600 mV)
19.99 V DC	15 V	10 mV	± (0.5% + 20 mV)
59.99 V DC	45 V	10 mV	± (0.5% + 60 mV)
199.9 V DC	150 V	100 mV	± (0.5% + 200 mV)
599.9 V DC		100 mV	± (0.5% + 600 mV)

- Metering temperature coefficient: ± 0,05%/°C of the value ± 0,02%/°C of the range.

- Possibility to say that the voltage input is a drop across a specified shunt. Shunt range: 1 to 1000 mOhm. In this situation the metering is converted into current, according to the formula:
I = V/Rshunt
The accuracy is the same as above.

- Possibility to display the voltage waveform.

2.8.3 Other measurements

As per main outputs, it is possible to compute measurements on external inputs. In this instance, measurements available depend upon the AC or DC selection for both inputs (no measurement for mixed selections).

N.	**PARAMETER , AC INPUTS**	**DERIVED FROM**	**FORMULA**	**UNITS**
1	ACTIVE POWER, P	Iext, Vext; f	P= I*V*cos (f)	W
	REACTIVE POWER, Q	Iext, Vext; f	Q= I*V*sin(f)	VAr
2	APPARENT POWER, S	Iext, Vext	S= I*V	VA
	POWER FACTOR, p.f.	f	p.f. = cos(f)	-
3	IMPEDANCE, Z and f	Iext, Vext, f	Z = V/I	Ohm, °
4	ACTIVE IMPEDANCE COMP., R	Iext, Vext; f	R = Z* cos(f)	Ohm
	REACTIVE IMPEDANCE COMP., X	Iext, Vext; f	X = Z* sin(f)	Ohm

5	FREQUENCY, F	Vext	-	Hz
6	PHASE ANGLE, IE TO V2	F , IE-V2; ref. V2	-	°
	PHASE ANGLE, VE TO V2	F , VE-V2; ref. V2	-	°

The angle measurement accuracy is ± 1° ± 1 digit. This accuracy applies to inputs greater than 10% of the input range, and for frequencies of 50 ± 0,5 Hz, and 60 ± 0,6 Hz. Temperature coefficient: ± 1 ppM/°C of the value.

The frequency measurement accuracy is ± 1 mHz ± 1 digit. This accuracy applies to inputs greater than 10% of the input range, and for frequencies of 50 ± 0,5 Hz, and 60 ± 0,6 Hz. Temperature coefficient: ± 1 ppM/°C of the value.

For other parameters, the accuracy is the sum of voltage, current and angle accuracies, as applicable.

PARAMETER , DC INPUTS	**DERIVED FROM**	**FORMULA**	**UNITS**
POWER, W	Iext, Vext	P= I*V	W
RESISTANCE, R	Iext, Vext	R = V/I	Ohm

2.9 DISPLAY

The graphical display has the following main features:

- pixels: 240x64
- backlight color: white
- LCD type: FSTN
- View area: 135x40

During the standard operation the display shows the measurements of: main AC current (or main AC voltage or main DC voltage, according to selection); auxiliary AC voltage; auxiliary DC voltage; elapsed time. To the left is the area for the access to the menu selection.

2.10 MENU SELECTIONS

The following is the list of features that are menu selected. The menu is operated by means of the control knob marked MENU, that incorporates a switch. The menu is entered pressing the knob and selecting the item moving the knob. Once the item has bee found and programmed, pressing the arrow the menu moves back of one step, so that other programming can be performed; else, selecting ESC the menu returns to the main window.

During this operation the display shows output measurements, in reduced format. After confirmation, menu messages disappear, and measurements are displayed in the standard format.

Any setting can be saved to and recalled from the memory. Up to 10 settings can be stored and recalled; setting no. 0 is the default one, and pops up at power-on. Settings are permanently stored in the memory; new settings can be written to the same address after confirmation. For normal mode operation it is possible to recall the standard setting, that cannot be modified.

During the test, test results can be stored in the memory (up to 500 results may be stored). At the end of test, settings and test results can be transmitted to a PC provided with TDMS. The software allows saving test results, examining them and so on. The specification of TDMS is given in a separate document. When the PC is connected, settings can also be created and transferred into T1000 using TDMS. The flux diagram of menu selections can be found in Appendix 1.

LEVEL1	LEVEL 2	LEVEL 3	LEV. 4	FUNCTION
TEST CONTROL	**Test mode**	Normal (default)		Measures the time delay from START (internal, external) to STOP (internal, external).
		Trip + pulse time		Measures the time delay from START (internal, external) to STOP (internal, external), and the duration of STOP.
		Reclose mode	TD; No. reclose	Two delays are measured: fault to STOP; STOP to START (reclose command). At START, a new fault is generated after TD (0-999.99 s), until the number of reclose (max 49) is reached.
	Fault injection	Maintained (default)		Generation lasts indefinitely
		Momentary		Generation lasts until the ON button is pressed
		External		Generation starts upon reception of the START input: this allows synchronising T1000.
		Timed	Max time	Generation lasts for the pre-set time duration. Max time 999 s.
		OFF delay	T delay	The main output OFF is delayed by the set amount of time or cycles.
	Output power	300 VA (default) – 60 VA		Selection of full (300 VA) or reduced (60 VA) power
	Save	Don’t save (default)		Test data are not saved
		Automatic, at trip		As relay trips data are saved to the next memory location
		Confirm, at trip		As relay trips data can be saved, after confirmation
		Manual		When selected, generated values are saved.
	Auxiliary contact	Timing		Sets the contact timing with respect to test start

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	FUNCTION
TIMER START/ STOP	**Start**	INT (default)		Timer starts when ON or ON+TIME are activated and outputs generated.
		EXT	NO-NC-EDGE	After ON or ON+TIME, timer starts on the external input. External START input Normally Open, or Normally Closed, or Both (EDGE).
			CLEAN-24 V – 80 V	After ON or ON+TIME, timer starts on the external input. External START input without or with voltage. If with voltage, two voltage thresholds are available: 24 or 80 V.
			COUNT	Timer enters the counting mode; it is possible to program the number of transitions prior to time measurement. After ON or ON+TIME, the test set waits for these transitions before measuring the time.
	Stop	INT		Timer stops when the current of the main generator is interrupted.
		EXT (def.t)	NO-NC-EDGE (def.t)	Timer stops when the STOP input is detected. External STOP input Normally Open or Normally Closed or Both (EDGE).
			CLEAN-24 V – 80 V	Timer stops when the STOP input is detected. External STOP input without or with voltage. If with voltage, two voltage thresholds are available: 24 or 80 V.
			COUNT	Timer enters the counting mode; it is possible to program the number N of transitions to be detected. After ON or ON+TIME, the time from the first valid input to input N+1 is measured; the corresponding energy can be read on the display.
	Timer	s (default)		Time duration metered in seconds
		cycles		Time duration metered in cycles

LEV. 1	LEV. 2	LEV. 3	LEVEL 4	LEVEL 5	FUNCTION
AUX VAC/ VDC	**Aux Vac con-trol**	Range			65 (default) ; 130 ; 260 V.
		Mode	Fault (default)		The auxiliary AC voltage is adjusted by the dedicated knob, and is always present, independently by test start. If the auxiliary voltage should be applied along with the main current or voltage, go to next selection.
			Prefault + Fault	Prefault Amplitude	Sets the pre-fault auxiliary AC voltage amplitude. Entering this selection in OFF mode the pre-fault voltage is immediately generated: pre-fault voltage is generated and displayed, and adjusted **by the multi-function knob**. The fault voltage is generated pressing ON or ON+TIME, and it is adjusted by the knob.
				Prefault Phase (0..359°)	Sets the pre-fault auxiliary voltage phase with respect **to the fault voltage**; the angle is adjusted by the multi-function knob. The pre-set value is not metered.
				Prefault duration	Sets the duration of the pre-fault auxiliary voltage. When ON or ON+TIME are pressed, the pre-fault will be generated at the mains frequency; then the fault voltage is generated, at the programmed frequency.
				Prefault frequency	The prefault frequency of the auxiliary voltage may be programmed. The frequency is applied with outputs OFF.
		Frequency	Locked to mains (default)		If "Locked", the auxiliary voltage is at the mains frequency.
			Adjust freq	40-500.000	The frequency of the auxiliary voltage may be programmed. Frequency changes at test start; output voltage does not change in amplitude.
			Adjust r.o.c.:	± 0.01.. 9.99 Hz/s	The frequency ramps at the programmed rate of Change. The starting frequency can be the mains or the value set by adjust freq.
		Phase	Locked to mains (default)		With this selection Vaux is in phase with the mains.
			Adjust phase Vaux - mains		The fault auxiliary voltage can be phase shifted with respect to the mains. The measured angle is displayed. Test must be ON; for a correct angle measurement, the auxiliary voltage must be more than 20% of the range. Phase is adjusted by the multifunction knob.
			Adjust phase Vaux – I main		The fault auxiliary voltage can be phase shifted with respect to the main current. The measured angle is displayed. Test must be ON; for a correct angle measurement, current and voltage must be more than 20% of the range. Phase is adjusted by the multifunction knob.
			Adjust phase Vaux – V main		The fault auxiliary voltage can be phase shifted with respect to the main voltage. The measured angle is displayed. Test must be ON; for a correct angle measurement, both voltages must be more than 20% of the range. Phase is adjusted by the multifunction knob.
	Aux Vdc control	Range			130 V (default) or 240 V. If this selection has to be changed, it's necessary to adjust the voltage output to the minimum by the dedicated knob.

LEVEL 1	LEV. 2	LEVEL 3	LEVEL 4		FUNCTION
METERS	**Internal**	Units of I	Normal		If selected, current values are displayed in A.
			I/IN	IN	If selected, displayed values are defined as I/IN, that can be defined.
		Units of V	Normal		If selected, voltage values are displayed in V.
			V/VN	VN	If selected, displayed values are defined as V/VN (phase voltage), that can be defined.
	External I	Enabled	AC (default) - DC		With selection AC the meter performs the true rms measurement; with selection DC, the measurement is performed on the average.
			10A – 20 mA		Selects the current input socket
			Waveform		If selected, the current waveform is displayed
	External V	Enabled	AC (default) - DC		With selection AC the meter performs the true rms measurement; with selection DC, the measurement is performed on the average.
			Shunt : 1 – 1000 mOhm		If the voltage is coming from a current dropping on a shunt, specifying the shunt value the current is displayed; default 100 mOhm.
			Waveform		If selected, the voltage waveform is displayed

LEVEL1	LEVEL 2	LEVEL 3	FUNCTION
METERS (continued)	**Other internal**	None (default)	No extra measurement displayed
		Active power	P; W
		Reactive power	Q; VAr
		Impedance module	Z, Ohm
		Impedance argument	f , °
		Active impedance component	R, Ohm
		Reactive impedance component	X, Ohm
		Apparent power	S; VA
		Power factor	p.f. = cos(f V-I)
		Active energy (AC)	Ea; Wh
		Reactive energy (AC)	Er; VArh
	Other external	None (default)	No extra measurement displayed
		Active power	P; W
		Reactive power (AC)	Q; VAr
		Impedance module	Z, Ohm
		Impedance argument	f , °
		Active impedance component	R, Ohm
		Reactive impedance component (AC)	X, Ohm
		Phase, I (AC)	f , Vmain-Iext; reference Vaux
		Phase, V (AC)	f , Vmain-Vext; reference Vaux
		Apparent power (AC)	S; VA
		Power factor	p.f. = cos(f V-I)
		Frequency of V (AC)	f, Hz
		Active energy (AC)	Ea; Wh
		Reactive energy (AC)	Er; VArh

LEVEL1	LEVEL 2	LEVEL 3	LEVEL 4	FUNCTION
RESULTS	**Delete**			Selected result(s)
				All results
CONFIGU-RATION	**Settings**	Save to address	1..10	Saves current settings to X
		Restore address	1..10	Restores settings from X
		Restore default		Restores default settings
	Language	UK, FR, SP, PT, GE, IT		Select the desired language
	Display	Speed	Slow	The displayed value is refreshed every 1000 ms
			Fast	The displayed value is refreshed every 300 ms
		Hold mode	Hold trip	As relay trips, test data measured 4 periods before trip are held.
			Hold min	As relay trips, the minimum value within 0.5 s is held.
			Hold max	As relay trips, the maximum value within 0.5 s is held.
	LCD Contrast			It allows to adjust the LCD contrast

Note: measurements marked AC apply only if both inputs are selected as alternate current.

2.11 OTHER CHARACTERISTICS

- Set of resistors, for the test of low impedance relays. Available values:

RESISTOR Ohm	POWER W	MAX CURRENT A
0.5	50	10
1	50	7
22	50	2.15
470	50	0.33
1000	50	0.22
2200	50	0.15

- Interface: serial RS232; baud rate 57600 baud.

- Mains supply: 230 V ± 15%; 50-60 Hz.

- Maximum supply current: 5 A.

- The instrument comes complete with the following items:
. Mains cable;
. User's manual;
. Serial cable;
. Spare fuses (no. 5), T5A ;
. Test cables: 2 m long, cross section 1 sq. mm, terminated with safety banana plugs: 4 black and 4 red.
. Ground connection cable: 2 m, yellow/green, terminated with crocodile clamp.

- Dimensions: 380 (W) * 300 (D) * 240 (H) mm.

- Weight: 19 kg.

2.12 OPTIONS

2.12.1 Power supply, code PII20093

This option is to be specified at order.

- Mains supply: 115 V ± 15%; 50-60 Hz.

- Maximum supply current: 16 A.

With this power supply voltage, maximum output power is limited to 1600 VA. As a consequence, the current outputs table becomes the following. Other performances are unaffected.

RANGE A AC	**CURRENT OUTPUT A**	**MAXIMUM POWER VA**	**LOAD TIME s**	**RECOVERY TIME min**
100	30	300	STEADY	-
	50		30 min	100
	75		600	45
	100	800	60	15
	160	1000	3	10
	-	-	-	
40	12	300	STEADY	-
	20		30 min	100
	30		600	45
	40	800	60	15
	60	1200	3	10
	-	-	-	-
10	5	400	STEADY	-
	7.5		15 min	45
	10	800	60	15
	15		5	10
	20	1000	2	5

2.12.2 Connection cable kit, code ZII18093

This option includes 17 cables in all, with different colours, 2 m long, with different cross section and terminations:
. Cross section 10 sq. mm, for current connection; terminated with headers: 2 cables;
. Cross section 1 sq. mm, all the others; terminated with safety banana plugs: 15 cables, of which 4 black; 5 red; 5 blue; 1 yellow/green.
These cables allow for the connection to the relay under test to the following sockets:
- Current outputs (2 cables, 10 sq. mm);
- Voltage outputs (4 cables : 2 red and 2 black);
- Measurement inputs (4 cables: 2 red and 2 black);
- Auxiliary output (2 cables: 1 red and 1 blue);
- Trip inputs (4 cables; blue);
- D/1000 option (2 cables, black, 0.5 m long, 1.5 sq. mm);
- Ground (1 cable; yellow/green).
The option includes also a crocodile (black) for the connection to ground.

2.12.3 Transit case, code PII17093

The transit case allows delivering T1000 with no concern about shocks up to a fall of 1 m.

2.12.4 "E" model: higher AC voltage outputs, code PII30093

In this model, AC voltage outputs are higher than in the standard version.

- Main AC voltage output. Available power and duty cycle: see table below.

RANGE V AC	VOLTAGE OUTPUT V	LOAD CONSUMPTION VA	LOAD TIME min	RECOVERY TIME min
500	500	100	STEADY	-
	500	150	10	45
108	108	20	STEADY	-

- Auxiliary AC voltage. Power: 30 VA, continuous duty, at full range; 40 VA for 1 minute. For lower voltages the limiting current is the following.

RANGE V	MAX CURRENT mA
65	500
130	250
500	62

All other performances are the same. To be specified at order.

2.12.5 D1000 differential relay test module, code PII40093

The differential relay test module D1000 allows for the test of the differential relay curve, and also of the harmonic restraint characteristic. The module performances are the followings.

- Input: from the test set auxiliary AC voltage output.

- Output: 0 to 5 A AC.

- Output power: 5 VA, that corresponds to a maximum load of 0,2 Ohm.

- Connection: the output current is connected in parallel to one relay branch, in order to make the differential current.

-Output current measurement: connected to the test set external measurement.

- Dimension: 325 x 290 x 290 mm

- Weight: 7 kg.

2.12.6 15 Hz auxiliary voltage output, code PII70093

The option allows to have the auxiliary AC voltage output down to 15 Hz. The option performances are:
. No auxiliary DC voltage output;
. Auxiliary AC voltage output: power is reduced to 20 VA; other characteristics are not changed.
The option has to be specified at order.

2.12.7 C model, code PII50093

With respect to the standard model, the following is the list of C model additional features.
. Added a push-button with light to start/stop the auxiliary AC voltage generation;
. Added a push-button with light to start/stop the auxiliary DC voltage generation;
. Added a second auxiliary contact, that allows simulating the Open and Closed CB contacts with different timings.
. Auxiliary contacts protection is a self-restoring internal fuse, rather than a re-triggering fuse.

2.12.8 FT/100 current filter, code PII41024

The filter unit type FT/100 is an option to be used with the T/100 or T/X000 relay test sets. It is connected in series to the relay under test, and guarantees a sinusoidal waveform also when testing current relays with reverse time characteristics, or with heavily saturating burdens, that tend to distort the current waveform.
- Current input ranges: 0.5 - 2 - 10 - 50 - 100 - 200 A, on terminal bushings.
- Maximum power yield: 800 VA.
- Filter burden: less than 200 VA at 200 A. The burden is proportional to the range (50 VA at 50 A).
- Service: 50 A continuous service; 200 A for 30 s.
- Selection of the mains frequency: 50 or 60 Hz, by switch.
- Overall dimensions: 220 x 250 x 310 mm.
- Weight: 15 kg.

2.12.9 SHA-1000 scanning head for T1000 and T3000, code PII43102

SHA-1000 is a scanning head that eases the test of energy meters. It is an universal scanning head because it can be used both with LED impulse electronic meters and Ferraris rotating disk meters; selection is performed via a switch located on the scanning head. In addition to this, a knob allows to adjust the sensitivity of the head.

With rotating disk the sensor uses a green light beam that optimizes the recognition of any type of mark.

With LED recognition the following specification applies:
. Impulse duration: more than 60 us;
. With an LED signal having a space ratio 1:2, the frequency must be less than 500 Hz.;
. Light wavelength: 500 to 960 nm (red: green and blue ARE NOT detected).

The option includes:
- The support that allows to keep the scanning head in front of the energy meter: maximum height 175 mm;
- The cable, 2 m long, from the scanning head to T1000 or T3000;
- The power supply transformer, for the power of 220 Vac, to supply the scanning head.
- Two safety banana plugs for the connection to T1000 or T3000.

3 PROTECTIONS

- Fuse on the mains supply.

- At power-on, a diagnostic sequence controls:
. Key microprocessor board components;
. Auxiliary supply voltages.
If something is wrong, the operator is alerted by a message.

- Thermal sensor on the main and auxiliary transformers. In case of over-temperature, an alarm message is displayed.

- Thermal sensors on the SCR that controls current injection, and of the internal temperature. In case of over-temperature, an alarm message is displayed.

- If the following current limits and time duration of main current outputs are trespassed, the generation is interrupted, and the operator is warned by an alarm message.

OUTPUT	**10 A**	**40 A**	**100 A**	**250 Vca**	**300 Vcc**	**Tmax**
I (A)	5	12	30	2	1	infinite
I (A)	10	40	100	3	2	60 s
I (A)	25	100	250	4	3	1 s

- If the current of 3.5 A is exceeded on main AC or DC voltage outputs, the generation is interrupted, and the operator is warned by an alarm message.

- The auxiliary AC voltage is protected by an electronic circuit that stops the voltage generation and opens the connection to outputs socket in case of overload (short circuit included). In case of intervention, an alarm message is displayed. Via the control knob the operator can reset the alarm and close the relay to restore operation.

- The auxiliary AC voltage is also protected by a thermo switch that intervenes in case of over-heating. In case of intervention, an alarm message is displayed.

- The auxiliary DC voltage is protected by a current limiter. The user notices the low voltage and removes the overload. The fuse protects the case of counter-feed.

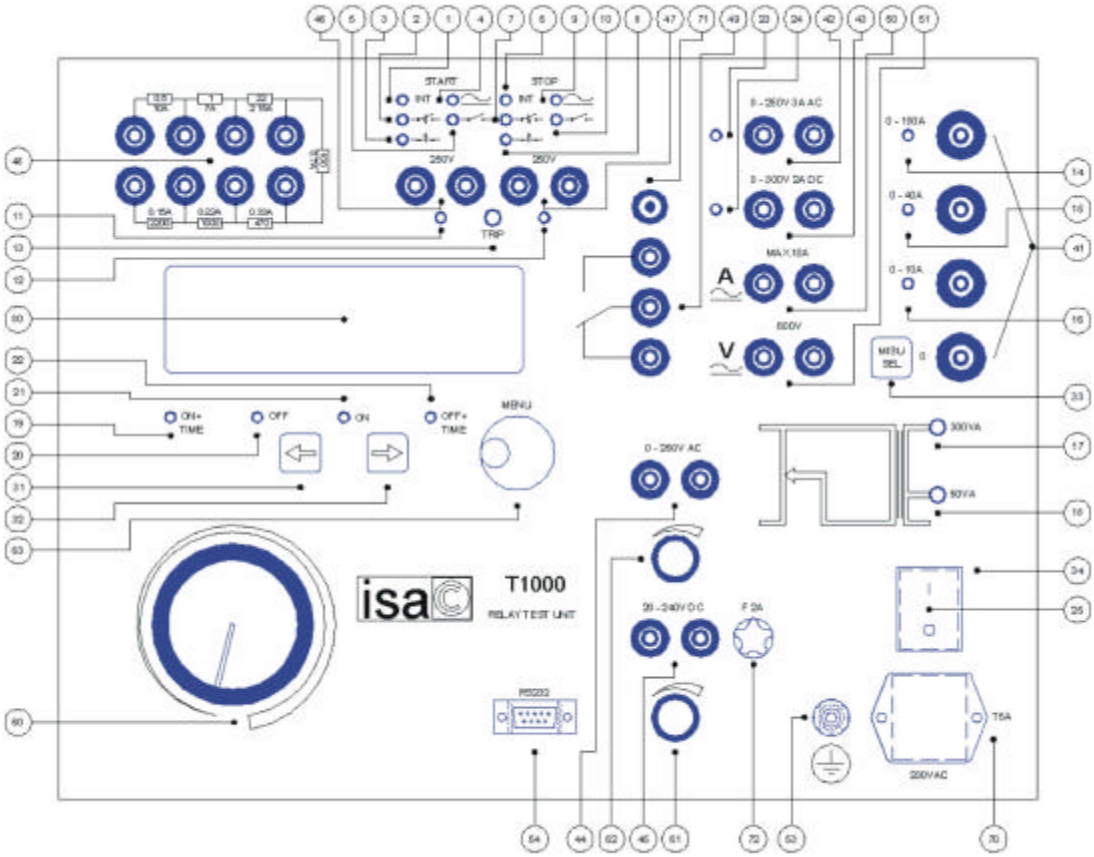
- Re-triggering fuse on the auxiliary contact.

- Timer inputs are protected against wrong selections. If the voltage free input is selected and a voltage is applied less than 250 V ac or 275 V DC, circuits will not be damaged.

- Trip inputs and the auxiliary relay contacts are protected by devices rated 380 V AC, that limit the maximum voltage between sockets and among sockets and ground. The same protection is applied to the auxiliary AC and DC voltage sources.

- The 20 mA measurement input is protected by a PTC against wrong connections: in case of error the PTC goes to high impedance. The PTC self-restores to the normal value in some minutes.

4 LEGEND OF DRAWINGS



1) Internal START selection light.
2) Normal Open START selection light.
3) Normal Closed START selection light.
4) Under voltage START selection light.
5) Voltage clean START selection light.
6) Internal STOP selection light.
7) Normal Open STOP selection light.
8) Normal Closed STOP selection light.
9) Under voltage STOP selection light.
10) Voltage clean STOP selection light.
11) START input closed or with voltage light.
12) STOP input closed or with voltage light.
13) TRIPPED condition recognized light.
14) 100 A range selection light.
15) 40 A range selection light.
16) 10 A range selection light.
17) Normal power selection light.
18) Reduced power selection light.
19) ON + TIME light: current is generated and time metered until STOP is detected.
20) OFF light: no current generation.

21) ON light: current is generated.
22) OFF + TIME light: current is removed and time metered until STOP is detected.
23) Main AC voltage selection light.
24) Main DC voltage selection light.
25) Power-on light (in the power supply switch)

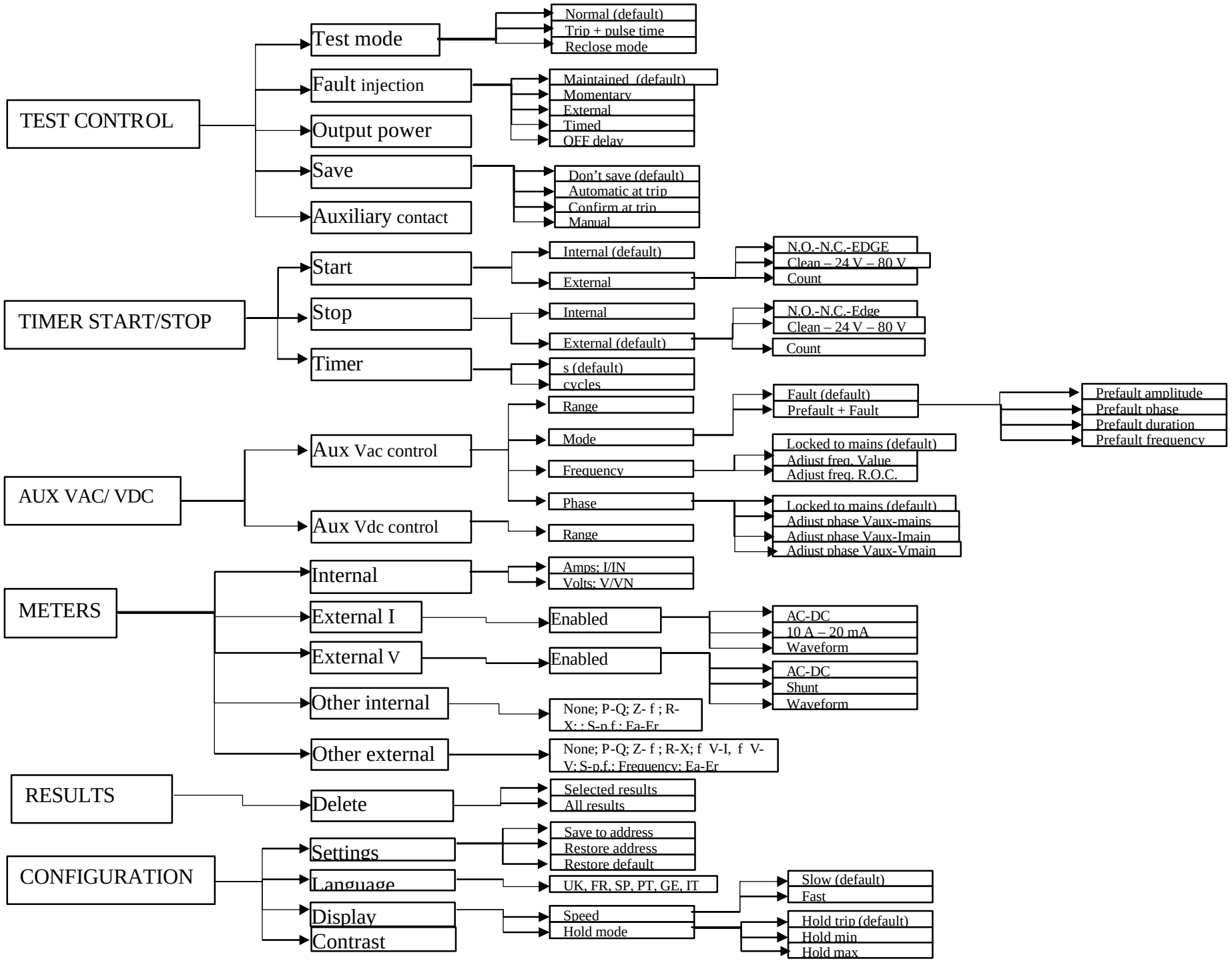
31 and 32) START and STOP push-buttons.
33) Push-button for the selection of main output.
34) Power-on switch.

41) Output sockets for main current output.
42) Main AC voltage safety sockets.
43) Main DC voltage safety sockets.
44) Auxiliary AC voltage sockets.
45) Auxiliary DC voltage safety sockets.
46) Sockets for the connection to the external Start input.
47) Sockets for the connection to the Stop input.
48) Resistors set.
49) Auxiliary Normal Open and Normal Closed contacts.
50) External current meter safety sockets.
51) External voltage meter safety sockets.
52) Socket for the mains supply.
53) Earth socket.

60) Main outputs adjustment.
61) Adjustment of auxiliary AC voltage output.
62) Adjustment of auxiliary DC voltage output.
63) MENU control knob, with switch.

70) Main supply fuse, rated T5A, incorporated in the supply socket.
71) Auxiliary contact protection re-triggering fuse, rated 4 A.
72) Auxiliary DC voltage fuse, F1A.

80) Display.



APPENDIX 1: MENU SELECTIONS FLUX DIAGRAM